MONTANA'S NATURAL RESOURCES

Montana Department of Commerce

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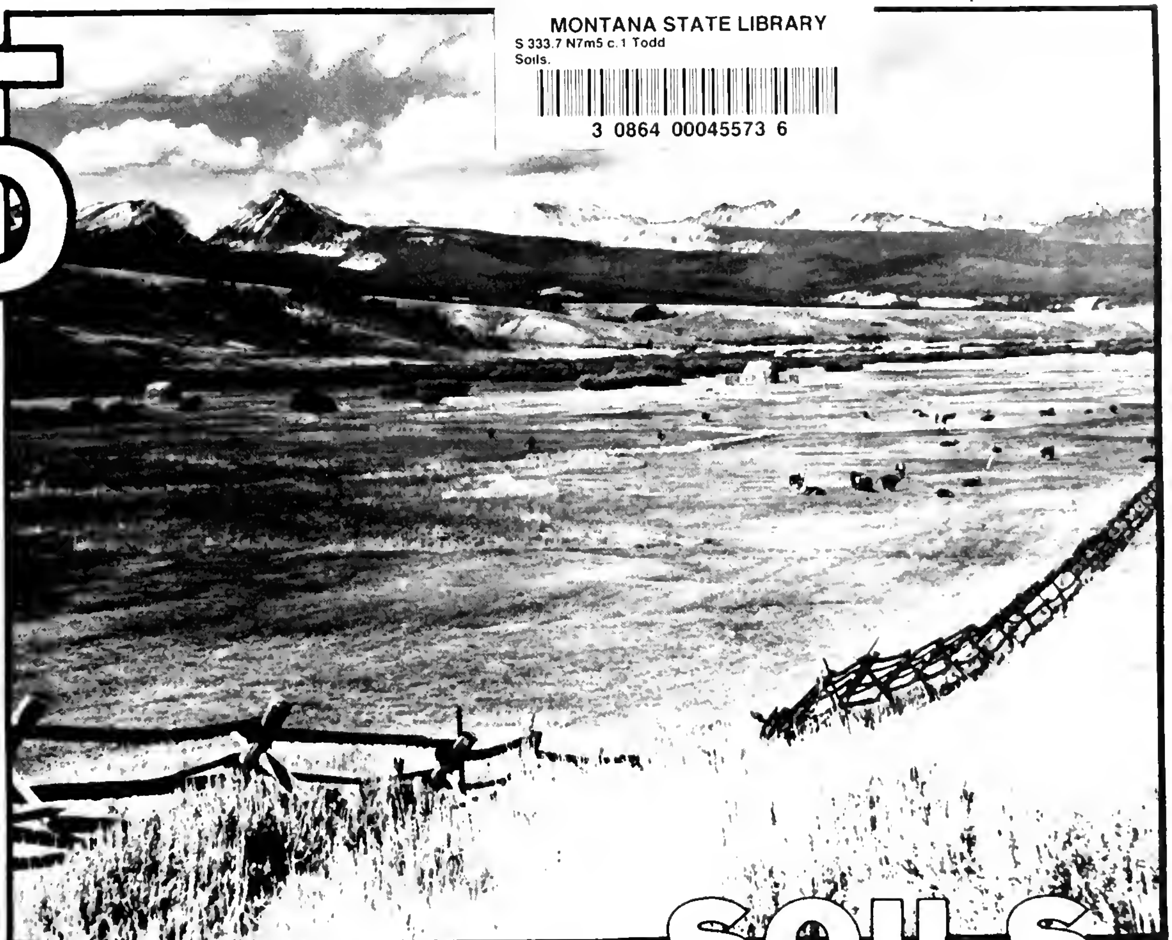


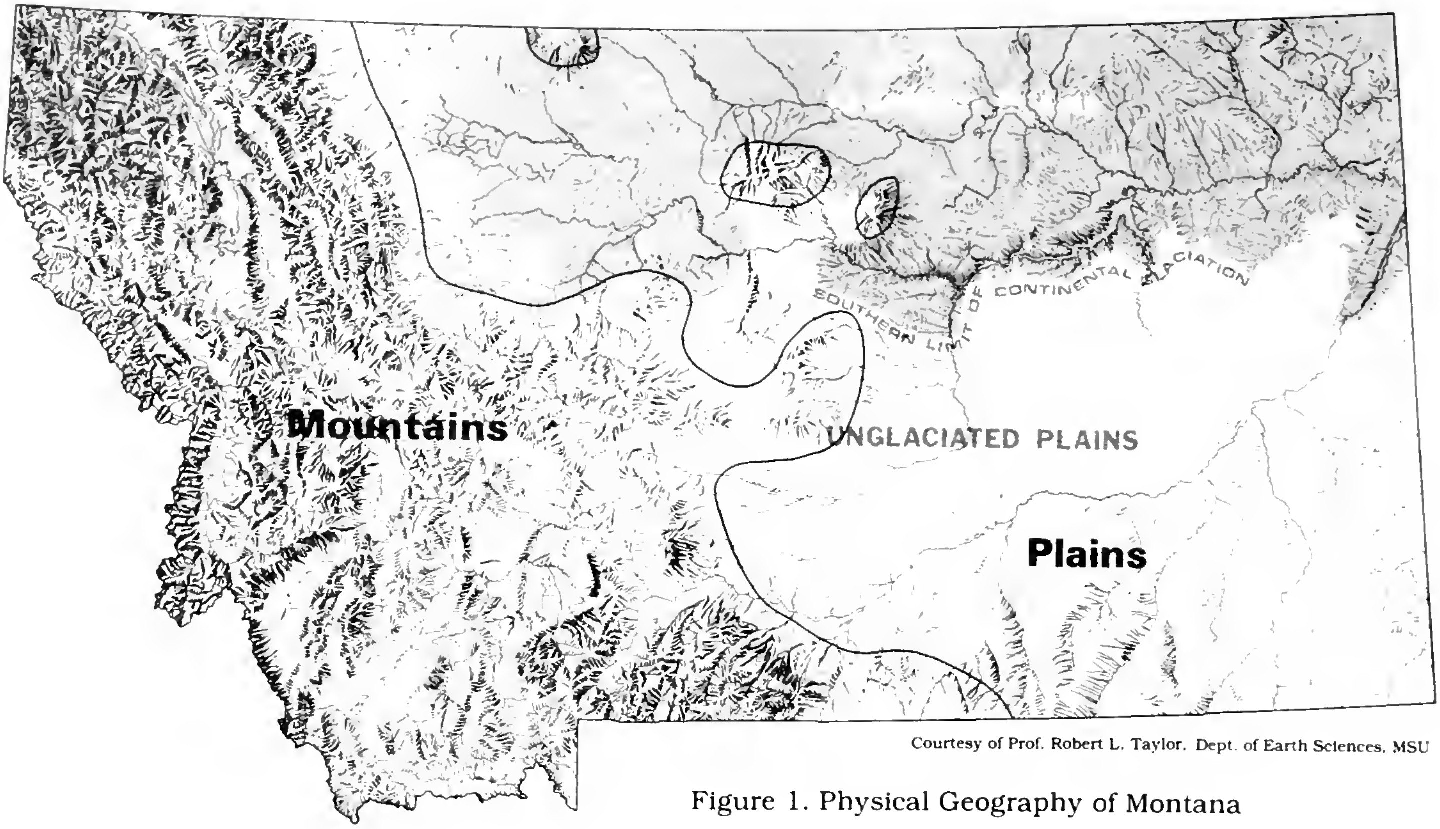
SOILS

"Gratitude to the earth. . .
and to her soil, rich, rare and sweet. . ."

—Gary Snyder

Over 700 different kinds of soils cover the 147,138 square miles of Montana. Even though there are so many types of soils, you can learn to identify the principal ones. The land forms in an area are a reliable guide to what soils occur there. For example, mountain terraces or benchlands like those in the cover photograph have thin soils lying over gravels and small stones or cobbles. Along the flat bottomlands and stream beds the deep soils have developed in material called alluvium that has been deposited by water.

The Montana Department of Natural Resources and Conservation thanks the Extension Service of Montana State University for the use of the adapted map of Montana's soils.



Courtesy of Prof. Robert L. Taylor, Dept. of Earth Sciences, MSU

Figure 1. Physical Geography of Montana

The general location of the mountains, benches, and plains of Montana are shown in figure 1. On the high mountain slopes, the coniferous forests grow in acid, light-colored, rocky soils. The foothills and the northern plains have soils that come from glacial till—material left behind by melting glaciers that once reached as far south as the Missouri River. Most of the plains of central and south-central Montana have thin soils overlying shales and sandstone bedrock.

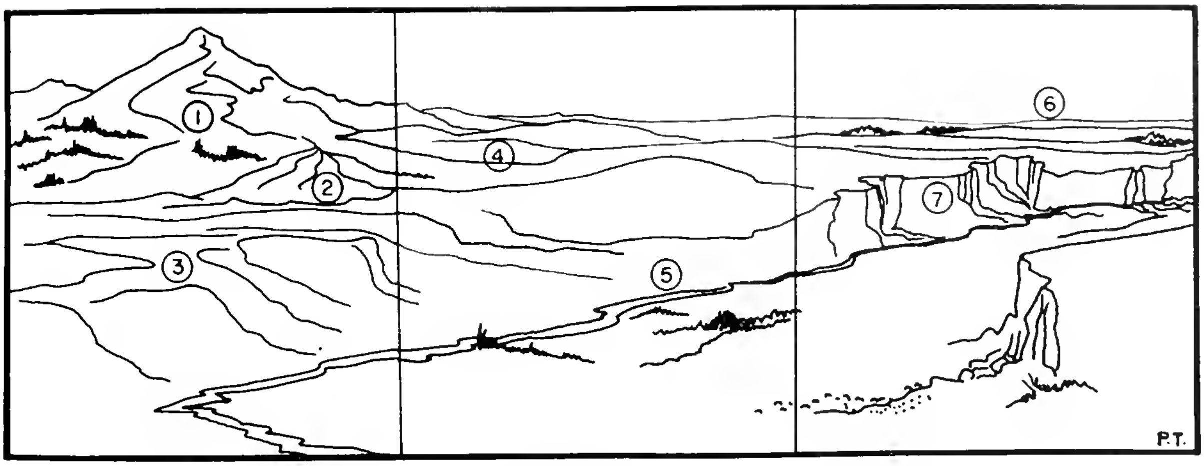
You may wonder why most of our soils are thin. There are two reasons: first, our part of the United States is young from a geological point of view; second, our climate is cool and dry (arid). Rocks weather (or break down) slowly into soil, and organic materials (the plants and animals that are the other sources of soil), decay slowly here.

The land forms of Montana can be easily identified across the state. Figure 2 shows them in a composite landscape. Two of these land forms are unique to this part of the west. The alluvial fans at the bases of some mountains were formed when glacial streams washed tons of gravel and rock out onto the valley floors below. The "breaks," rough gullied land like that along the Missouri River, have light-colored, hard, clay soil with a high lime content.

How is Soil Made?

Maybe you've never thought about where soil comes from, or how solid rock can become part of the earth where grass, trees, and crops grow. Wind erosion over great periods of time may, for instance, change sandstones to sand. But broken or eroded rock is only one ingredient of soil. Soil is made by powerful natural forces, which work so slowly that it takes a long time for their work to be seen. Wind, water, changes in temperature, and the slow addition of dead plants and animals are all part of this process. Water carries minerals and acids from surface vegetation into the soil. Freezing temperatures can cause water in rocky crevices to freeze and expand, gradually breaking the rock into smaller pieces.

Both physical and chemical changes (weathering) alter the rocks and soils. Besides freezing, other physical changes can happen. For instance, the seed of a pine tree caught in a crack of rock may produce a



1 Forested Mountains
2 Alluvial Fan
3 Benches and Terraces
4 Foothills
5 Alluvial Valleys
6 Plains
7 Breaks

Figure 2. Principal Land Forms of Montana

tree whose roots can split the rock as the tree grows (figure 3). A chemical change can occur when the organic acids given off by plants change the composition of the soil. When this happens, other plants that couldn't grow in that location before may be able to grow in the altered soil.

Figure 3. Weathering

What Makes One Soil Different From Another?

Many country roads in central Montana and elsewhere in the state are very slick when they get wet. We call them "gumbo" roads. The reason they become so slippery is that the ground they're built on has clay soil that holds water.

Five things determine what kind of soil will be in a certain place: 1) the mineral and chemical makeup of the "parent" material; 2) the climate that prevailed when the soil accumulated and weathered; 3) what kinds of plants and animals lived on and in the soil; 4) the slope and aspect of the land where the soil lies—that is, which direction the slope faces; and 5) how long natural forces have acted on the soil material—the age of the soil.

Soil Classifications

Worldwide, soils have been divided by scientists into ten orders or groups. Five of these soil orders occur in Montana:

Mollisols (moll′· i · sol) contain dark organic materials (humus), have a rich top layer, and are found primarily in grasslands as well as in some wooded areas.

Aridisols (arid′· i · sol) are light-colored soils found in grasslands or shrublands in arid regions.

Alfisols (alf′· i · sol) form under moist forests, have a light brown subsoil clay horizon, and medium to high fertility. ("Horizons" are explained on page 6.)

Inceptisols (in · cept′· i · sol) form under forests or grasslands, and are an early stage of soil development—it is difficult to see any horizon separation in these soils.

Entisols (en′· ti · sol) have even less development—they are very "young" soils, either because of lack of moisture, recent changes in the landscape, or erosion.

Major Kinds of Soil in Montana

The map on the following page tells better than words the complex story of soils in Montana. Each of the different patterns shown indicates one type of land area and the soils that predominate there. Each land area covers hundreds (or thousands) of acres, and besides the principal soil type, has others in smaller amounts. One field may have many different soils, depending on its slope, aspect, and when and how the soils were formed. Generally, however, you could expect to find that most of the soils in a particular area would be those indicated on the map (figure 4.)

A

Montana's northern plains were covered by glaciers many thousands of years ago. The soils indicated on the map as "A" soils were all formed from glacial till—the material left as those glaciers receded. Most of this land area is arid to semiarid. The locations of the soil orders and their uses are explained below.

A^1 — Mollisols are found on the rolling glacial till plains, and terraces or benchlands formed by glacial outwash. The western part has a small percentage of Aridisols on the clayey terraces, fans, benches, and the basins that were left by glacial lakes. Use: dryland farming and rangeland.

A^2 — On the central till plains, Aridisols occur on the rolling plains, with Entisols and Ardisols in the hilly sections. Mollisols are found on the nearly level areas of the eastern portion. Use: dryland farming.

A^3 — On the eastern glacial till plain, Mollisols and Entisols occur on the rolling plains, with Entisols dominating on the hilly sections. Use: dryland farming and rangeland.

B

The soils of the dry central plains of Montana occur over sedimentary bedrock. These soils are indicated on the map as "B" soils.

B^1 — These plains and hills have "young" soils, the Entisols and Aridisols of the grasslands and shrublands. Some Mollisols are found in the western-most portion of this area. Use: rangeland, dryland farming.

B^2 — Montana's southeastern plains have a semiarid to subhumid climate, and soils are Entisols, Mollisols, and Inceptisols on the sedimentary bedrock plains and hills. On the gently sloping land forms, Mollisols are the major soils. Use: rangeland and dryland farming.

B^3 — On the clayey-shale plains, soils are Entisols and Aridisols. This area also includes badlands and the steep slopes of the river "breaks" where Entisols predominate. Use: rangeland.

C

Mountain foothills, terraces, and benchlands with an arid to subhumid climate have soils indicated on the map as "C" soils.

C — Soils on the high foothills are mostly Mollisols, with some Inceptisols. On the lower foothills, benches, and terraces, the soils include Mollisols, Aridisols, and Entisols. The steep, arid areas have mainly Aridisols and Entisols. Use: rangeland, with dryland farming on the gently sloping areas.

D

In Montana's mountains, soils of the open forest-grassland mingle with rocky outcrops and peaks. The climate is humid to subhumid. These soils are "D" orders.

D^1 — On the steep forested mountains the soils are Inceptisols and Alfisols, with both Inceptisols and Mollisols on the open forested grasslands. Uses: timber, rangeland, watershed, and recreation.

D^2 — In the humid forested mountains the soils are Inceptisols and Alfisols in the steep areas, and these soils occur on the valley and foothill moraines left by glaciers. Uses: timber, watershed, and recreation.

D^3 — Mountain forest soils in the humid northwest are mostly Inceptisols with volcanic ash that accumulated there when ash drifted from volcanic action along the Pacific range in Washington and Oregon. These soils are unstable and erode easily. Uses: timber, watershed, and recreation.

E

The fifth of the five soil orders found in Montana are the "E" soils of the northwestern mountain valleys, where the climate is semiarid to humid, with warm dry summers and moist winters.

E — The mountain foothills, glacial moraines, and terraces contain Mollisols. On the drier terraces Aridisols are most common. Uses: orchards, rangelands, and crops.

Figure 4. Soils of Montana

Soil Horizons

Look closely at the next road cut you drive through, and you'll see what are called "horizons"—usually three layers that are noticeably different from each other (figure 5). They lie roughly parallel to the surface, and consist of topsoil, subsoil, and "parent" material. The topsoil in Montana's hills and mountains usually has lighter, brighter colors. This soil contains living plants and humus—the remains of animals, insects, plants, and other decayed materials.

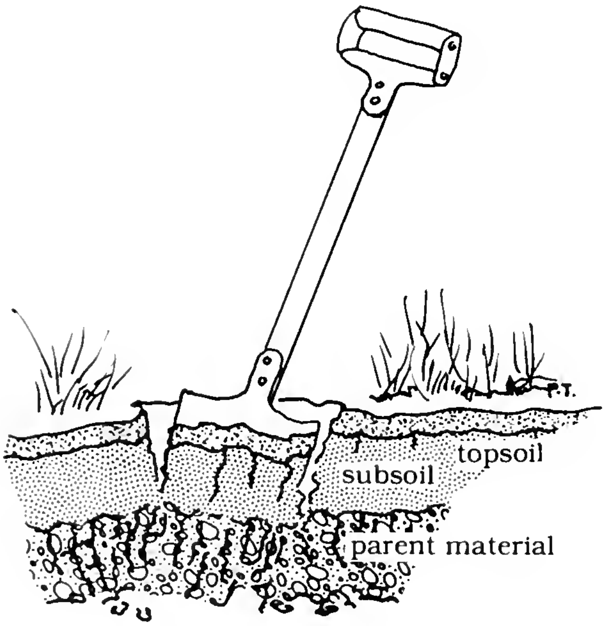


Figure 5. Soil Horizons

Subsoil, the second layer, is usually lighter in color than the topsoil; on the central plains of Montana it is often a light gray or tan. This layer contains some humus but very little living matter, and holds moisture well.

The deepest layer in the horizon, the parent material, is the original source of soil. On Montana's north central plains it is glacial till, composed of sand, silt, and clay. In the western mountains the parent material may be igneous or sedimentary bedrock while the southeastern plains soils are developed on soft sedimentary rocks. Parent material contains little organic matter, but can be an important source of water, especially if the overlying soils are dry.

Soil Structures

The separate parts of a particular soil tend to have certain shapes or soil structures called peds. You may want to learn to identify the types of soil structures by their shapes, as shown in figure 6. *Granular* peds are light and crumbly, and are found in dark topsoil. *Platy* peds are easily identified by their flat layers, and appear in pale soil below the surface. *Blocky* peds occur in subsoil that has a large amount of clay in it. Subsoils in grasslands like those in central Montana have a *prismatic* ped structure, and a *columnar* ped occurs in some of our grassland subsoils that have excessive sodium.

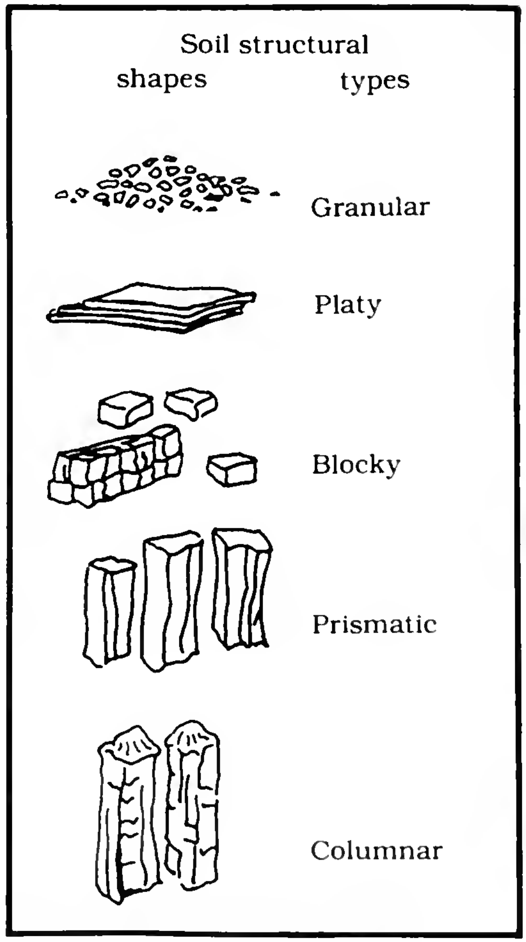


Figure 6. Soil Structures

The same forces that make soil from parent material will also gradually produce different structures in soils. Plant roots may break a soil into smaller pieces. Freezing and thawing, moisture and dryness, and the action of earthworms, ants, and burrowing animals—all can change soil structures over a period of time.

Man can alter natural soil structure by excessive tillage and by changing the soil/water relationship as has happened in the farming practice called crop/fallow (see the Water chapter).

Texture and Color

Texture and color are additional clues to the kind of soil in a particular place. You can tell a lot about soil by taking a handful and rubbing it through your fingers. A sandy soil feels coarse and grainy. Silty soil feels powdery when dry and slippery when moist, and clay soil will hold the imprint of your fingers if you squeeze it in your hand. When all three of these soil "separates"—sand, silt, and clay—are mixed in the proper amounts, they form a loamy soil.

Different colors in soil are due to organic matter, iron, and lime. A band of red shows that iron has acted with oxygen and that little moisture has penetrated the soil. Some soil horizons may be a blue-gray, indicating poor soil drainage. A light-colored horizon would usually show high lime content. However, in Montana's forests, a light layer just below the surface indicates leaching (or filtering out) of organic matter, iron, and lime. It does not indicate an accumulation of lime. Even though the forest soils receive more moisture, the woody material of forest litter breaks down more slowly than the vegetation on our grasslands. Plains soils have a darker color because they have more organic materials in them.

Montana's Soil Problems

Most of Montana's soil problems can be traced to misuse by humans. Often people haven't understood that certain types of soil weren't suitable for farming. The soil might produce well for a few seasons, and then its organic material was used up, drawn out by crops and not replaced.

In some cases, plowing alone did the damage; in others, farming methods left the land exposed for a season or more; gullies formed during heavy rainshowers, and valuable topsoil was also washed away. Too many grazing animals were put on land that couldn't support them. This land lost ground cover and became badly eroded by wind and water. It took many years for this land to recover even a part of its fertility; however, progress has been made.

Shelter belts—rows of shrubs and trees—have been planted to break the wind's force. Strip farming, which leaves bands of vegetation between plowed fields, also works to stop erosion by wind and water. Saline seep (which is explained in the Water chapter of this series) is another soil problem that can be partially corrected by seeding to alfalfa, a deep-rooted forage plant that uses the excess water in the soil.

Another problem that isn't fully recognized is that agricultural land in Montana is being converted to other uses—cities and towns expand into the country. So do highways, airports, homes, and recreation areas. Some of these uses could be shifted to marginal land that would be adequate, leaving the best soil for crops.

Suggested Class Projects

1. Compare soils from different locations by getting good topsoil, subsoil, and some from an excavation site or a field that has been cropped for many years. Put each soil in a flowerpot and plant 3 or 4 beans in each. (Soaking the beans overnight will make them germinate faster.) Water them and keep them in a sunny place. Plant some beans in cotton and keep them moist. Keep a record for a few days of how well the beans grow. How do the ones in soil compare with those in cotton? The topsoils with organic material should produce strong growth because they contain minerals and other nutrients.

2. Ask your local Soil Conservation Service agent to tell your class about some of the soils in your area and what farmers do to prevent erosion and other problems.

3. Read about the early days of farming on the western frontier in "Giants in the Earth," by Ole E. Rolvaag and "My Antonia," by Willa Cather.

Further Reading

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Soils of Montana. November 1982. Clifford Montagne et al. Montana Agricultural Experiment Station, Montana State University, Bulletin 744. Bozeman.

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* *The Story of Soil.* 1971. Holmes-Allen, Dorothy. G.P. Putnam's Sons. New York.

* Student reading.

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The Montana Department of Natural Resources and Conservation has had many requests for information about the minerals, water, forests, and other resources in Montana. This booklet is one of a series presented to answer some of those questions and to stimulate an interest in the natural resources of Montana. The University of Montana cooperated with DNRC in preparing the series which was financed in part by a federal grant made under Title 1 of the Higher Education Act of 1965.

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